Natural Hazards
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Lecture – 06
Introduction to Natural Hazards (Disaster Management)

Welcome back.

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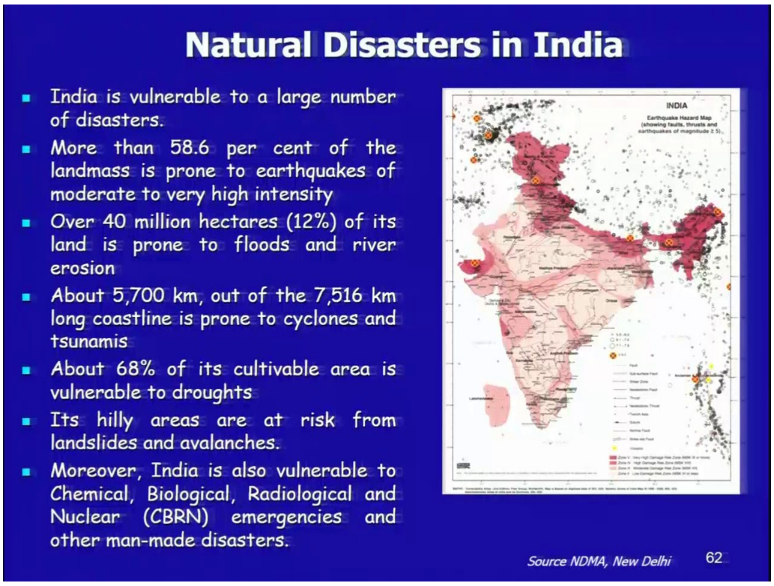

So, this was the last slide where we discussed about natural disaster in India.

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Now, as I was talking about that there are many agencies at national as well as at state level; who have taken proactive actions or may be the initiatives to minimize the hazard in different ways. So, this is what in the image talk about is that disaster management is one of the most important activity which can reduce in total the life loss as well as the property loss reading any kind of disaster. So, what is important is the that what we talking is today also and the previous lecture that this is an preparedness.

So, there are many mitigation part. So, any disaster occurs then there has to be any immediate relief and this will depend on the preparedness. So, before an event comes what is your preparedness and what is your understanding about that event is extremely important. So, immediate response has to be there otherwise if you delay you are going to see more number of facility or the number of people get getting killed will increase; if the relief is not been given immediately. And then so assessment is important so that will help us in the way that how we are going to deal for the reconstruction and the rehabilitation.

The people who got affected, injured lost their houses and all that how we are going to re-habitalize and actually that is very important. Of course, to some extent we can prevent, but I would say that you can just minimize the hazard or the risk part if you are having good capacity building. And this capacity building is an process what we talk about the mitigation and the preparedness So, disaster risk in India are further compounded by increasing vulnerability related one is changing demographic and socio economic conditions.

So, we see that our few states are over populated people have moved or migrated from one area to another area depending on the socio economic conditions. And of course, if you are having in the rural areas the construction pattern need not be up to the mark to withstand any disaster any kind of disaster then the life loss as well as the property loss will be much higher. So, this is another part is unplanned urbanization. Now without having the preparedness or the understanding of the hazard we are going very fast in terms of development.

So, unplanned urbanization development within high risk zone. So, when we understand the hazard and which areas are prone to the particular hazard then according to that there will be the zonation as for example, in the previous slide we were talking about the micro zonation or macro zonation of India which has been given relate based on the earthquake history not the whole India can be subdivided into four categories from zone 2 to zone 5. So, depending on the different hazard you have there is zones which could be allocated and based on that you can minimize the hazard.

But to some extent we what we experience the that is heavy loss in terms of or the building collapse or may be the property getting affected as well as people is because of unplanned urbanization development within high risk zones. Environmental degradation climate change geological hazard and epidemics will also add into the more disasters. All these contribute to a situation where disasters seriously threaten India’s economy it is population and sustainable development. Because any country the development of any country will depend upon the sustainable growth in types of economy is terms of the infrastructure also. Now if that is going to be disturbed we are definitely going to be affected towards our growth.

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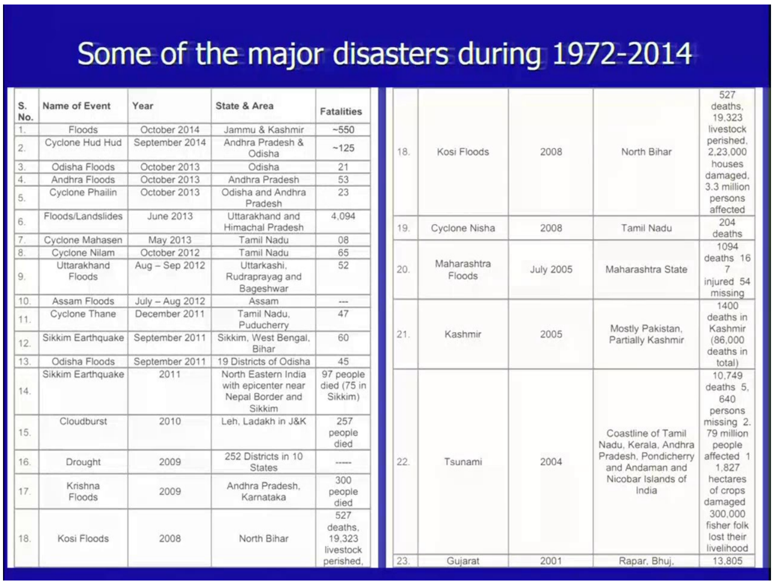

Some of the major disasters during 1972-2014

S. No.	Name of Event	Year	State & Area	Fatalities
1.	Floods	October 2014	Jammu & Kashmir	~550
2.	Cyclone Hud Hud	September 2014	Andhra Pradesh & Odisha	~125
3.	Odisha Floods	October 2013	Odisha	21
4.	Andhra Floods	October 2013	Andhra Pradesh	53
5.	Cyclone Phailin	October 2013	Odisha and Andhra Pradesh	23
6.	Floods/Landslides	June 2013	Uttarakhand and Himachal Pradesh	4,094
7.	Cyclone Mahasen	May 2013	Tamil Nadu	08
8.	Cyclone Nilam	October 2012	Tamil Nadu	65
9.	Uttarakhand Floods	Aug – Sep 2012	Uttarkashi, Rudraprayag and Bageshwar	52
10.	Assam Floods	July – Aug 2012	Assam	---
11.	Cyclone Thane	December 2011	Tamil Nadu, Puducherry	47
12.	Sikkim Earthquake	September 2011	Sikkim, West Bengal, Bihar	60
13.	Odisha Floods	September 2011	19 Districts of Odisha	45
14.	Sikkim Earthquake	2011	North Eastern India with epicenter near Nepal Border and Sikkim	97 people died (75 in Sikkim)
15.	Cloudburst	2010	Leh, Ladakh in J&K	257 people died
16.	Drought	2009	252 Districts in 10 States	-----
17.	Krishna Floods	2009	Andhra Pradesh, Karnataka	300 people died
18.	Kosi Floods	2008	North Bihar	527 deaths, 19,323 livestock perished,
18.	Kosi Floods	2008	North Bihar	527 deaths, 19,323 livestock perished, 2,23,000 houses damaged, 3.3 million persons affected
19.	Cyclone Nisha	2008	Tamil Nadu	204 deaths
20.	Maharashtra Floods	July 2005	Maharashtra State	1094 deaths 16 7 injured 54 missing
21.	Kashmir	2005	Mostly Pakistan, Partially Kashmir	1400 deaths in Kashmir (86,000 deaths in total)
22.	Tsunami	2004	Coastline of Tamil Nadu, Kerala, Andhra Pradesh, Pondicherry and Andaman and Nicobar Islands of India	10,749 deaths 5, 640 persons missing 2. 79 million people affected 1 1,827 hectares of crops damaged 300,000 fisher folk lost their livelihood
23.	Gujarat	2001	Rapar, Bhuj,	13,805

These are few examples of major disasters which occurred during 1970 up to 2014. This is we are talking about 2014, 2015 it was in Nepal well of course, you can add more here as we were giving in examples in the beginning itself or we had like 2018 flood in Kerala. So, similarly you have many hazard, but if you look at different type of different hazards here during flood cyclones you have list of and it has affected many areas. Coming to earthquake, tsunamis, earthquake in Kashmir 2005, floods in Maharashtra, cyclone Nisha, Kosi flood in 2008.

So, this was also again and very deadly event in terms of the if the flooding event in Bihar because of the Kosi flood. So, you can look at and then another one is that since last couple of years we have been hearing about the cloudburst that is sudden pouring down of the water from sky is cloudburst and which resulted into the landslide in Ladakh that was in 2010 then earthquakes floods earthquakes and all that.

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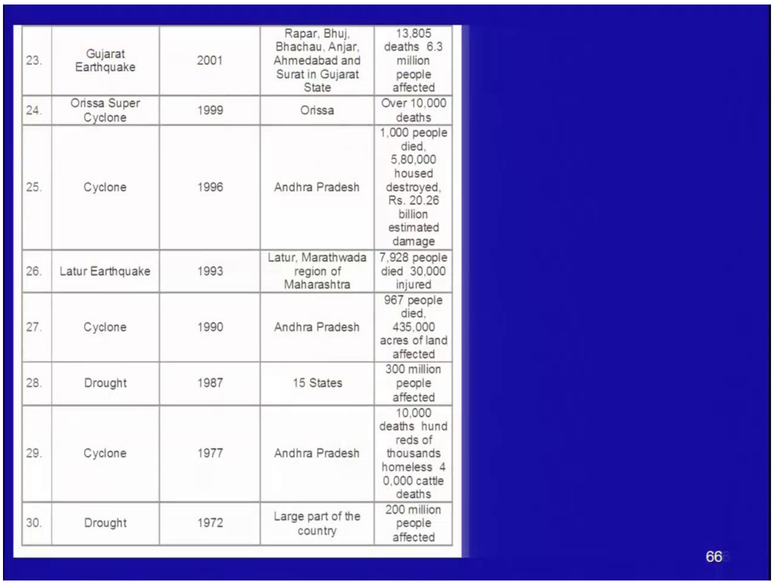

23.	Gujarat Earthquake	2001	Rapar, Bhuj, Bhachau, Anjar, Ahmedabad and Surat in Gujarat State	13,805 deaths 6.3 million people affected
24.	Orissa Super Cyclone	1999	Orissa	Over 10,000 deaths
25.	Cyclone	1996	Andhra Pradesh	1,000 people died, 5,80,000 housed destroyed, Rs. 20.26 billion estimated damage
26.	Latur Earthquake	1993	Latur, Marathwada region of Maharashtra	7,928 people died 30,000 injured
27.	Cyclone	1990	Andhra Pradesh	967 people died, 435,000 acres of land affected
28.	Drought	1987	15 States	300 million people affected
29.	Cyclone	1977	Andhra Pradesh	10,000 deaths hund reds of thousands homeless 4 0,000 cattle deaths
30.	Drought	1972	Large part of the country	200 million people affected

So, you have several such events which goes back up to 1972 which talks about the different kind of hazard which includes floods, earthquakes, landslides, tsunamis and so on.

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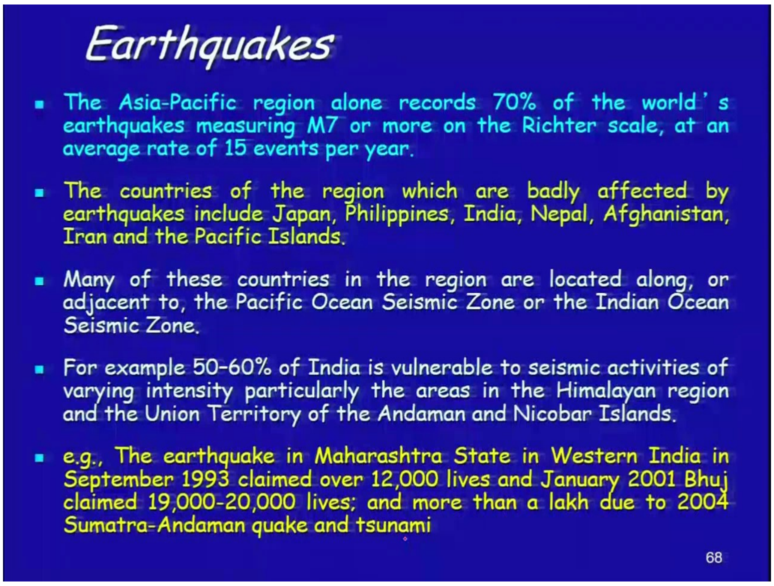

Now, coming to earthquake let us see quickly what we learn about this, but of course, we will be talking in detail later on. In general the Asia Pacific region alone records 70 percent of world's earthquake measuring magnitude 7 or more on Richter scale. At an average if we take 15 events are occurring per year that is on magnitude 7. In this particular area that is a Asia Pacific region. The countries of the region which are badly affected by earthquakes includes Japan, Philippine, India, Nepal, Afghanistan, Iran, and Pacific Islands.

Now if we talk about Japan here the preparedness, the awareness about different events is so high amongst the community or the society that they are able to minimize the hazard or the risk in all senses. But in India if similar magnitude earthquake occurs or in Afghanistan, Philippine number of toll will go high. That is number of facilities or people getting killed or people getting injured and property loss will be much higher.

Many of these countries in the region are located along or adjacent to pacific ocean seismic zone or the Indian ocean seismic zone. We will come to this what do you mean by seismic zone and what is the pacific seismic zone and Indian ocean seismic zone. But in short I can talk about this quickly is that Indian ocean seismic zone is the zone along which 2004 earthquake took place that was of Sumatra Andaman magnitude was 9.2 and it also triggered the devastating tsunami. For example, 50 to 60 percent of India is vulnerable to seismic activity.

So, in one of the slides we are talking about the coastal areas we are having the coastal regions or the coast line which is more than 7500 kilometres out of that almost like 5000 is vulnerable that is what we talk here. That even the land area including the land area also almost like 50 to 60 percent. So, more than half of the Indian plate or the Indian peninsula is or Indian sub continent we can say is vulnerable to seismic activity. And, that also of varying intensity particularly the area in Himalaya, Himalayan region and the Union Territory of the Andaman and microbar.

So, if I quickly draw an very rough sketch here. So, this is your Indian northern part then it comes down here and then we have something like that a very rough sketch I am putting in. And then we have the islands which was sitting here. So, this is an Andaman sub diction zone and this part is your Himalayan collision zone. So, and apart from there so this is one zone which is very dangerous and other zone is here third is here and that is in the Kachchh region. And one is which is Narmada zone area which is in the centre. So, most of the area is under the threat of a seismic activity.

So, example if you look at because if you say if more than 50 to 60 percent area is vulnerable to seismic activity. We have experience the earthquakes and the region which were been considered as an stable continental regions, like the earthquake in Maharashtra state in Western India in September 1993 claimed almost 12000 lives. And in January 2001 that was an Bhuj earthquake claimed almost 20000 lives and more than a lakh due to 2004 Sumatra Andaman earthquake. So, these are very like if we look at in 20th century we had couple of earthquakes and in 21st century we had a damaging earthquakes like 2001 and 2004 Sumatra Andaman which also accompanied the tsunami.

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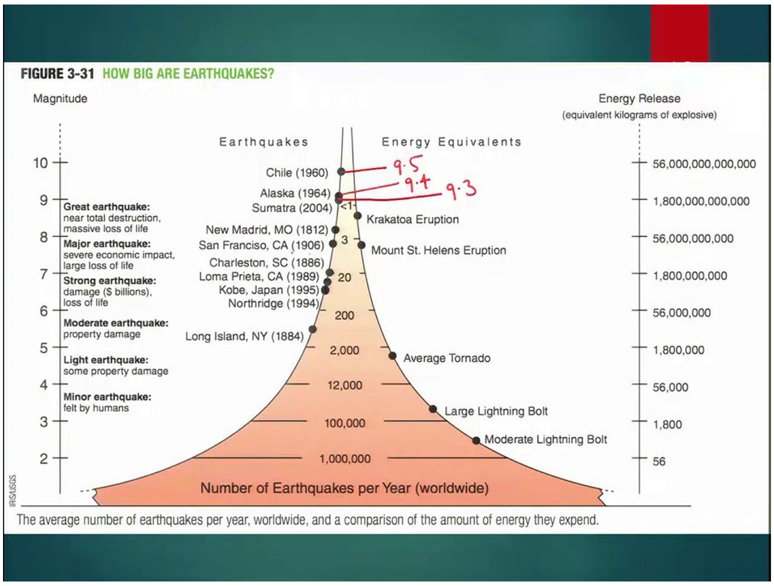

Now, in most of the literature we will find this correlation between the average number of earthquake per year worldwide and a comparison of the amount of energy the expand. So, the amount of energy released is compared with the energy released here which is equivalent in kilogram of explosives. So, 2004 here it is been listed close to the second largest one.

And in some literature it says the 1964 was comparatively or maybe we can say little bit larger there is compared to 2004, but the largest was 9.5 this was the Chilean earthquake of 1960 9.5. Alaska is been put somewhere around 7.4 or 9.4 or 9.3. And this was around 9.3. So, this becomes almost close to the second largest one. And then if you look at here it is not been listed, but 2001 Bhuj earthquake will lie somewhere here, it was 7.8 magnitude.

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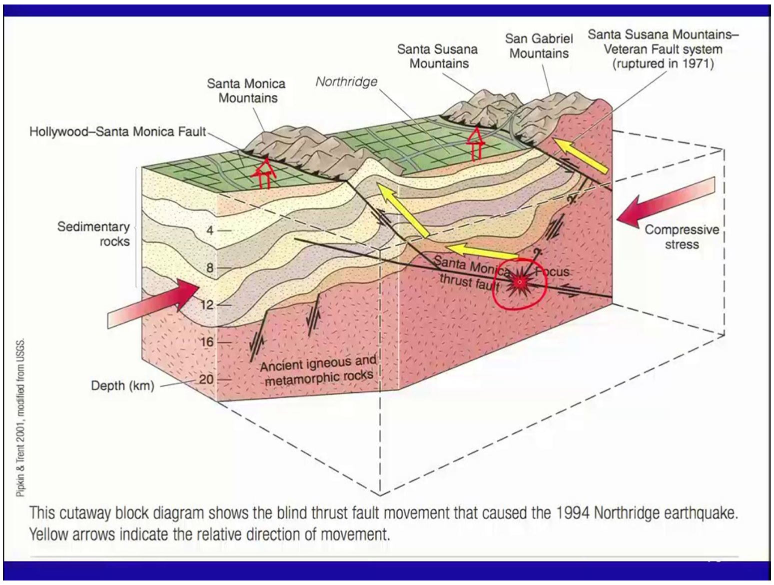

Another important point which we will be talking later, but right now while just quickly discussed is that. We are basically interested in knowing that how deep the earthquake will be, how far the earthquake will be from a particular sight. Suppose we are having some town sitting here then how far will be my efficient to from that particular region. Another part what will be what is the sight condition, like here what is been shown is this dotted layers are all sedimentary rocks. And then we have the deeper part are very hard massive rocks, very old ancient rocks. So, the ground acceleration in this rocks will not be so affective as compared to which we will experience in the softer material.

So, how far my earthquake epicentre will be from the sight of interest or my particular side where the population is there. And what are the features which one can identify this are we are going to talk in coming lectures about when we are talking about the earthquake. The two important point which you should remember is that what will be the sight condition where you were going to go for the construction or the development or where we were staying at present. How far is the source located of particular earthquake that is an epicentre where is the expected epicentre will be located.

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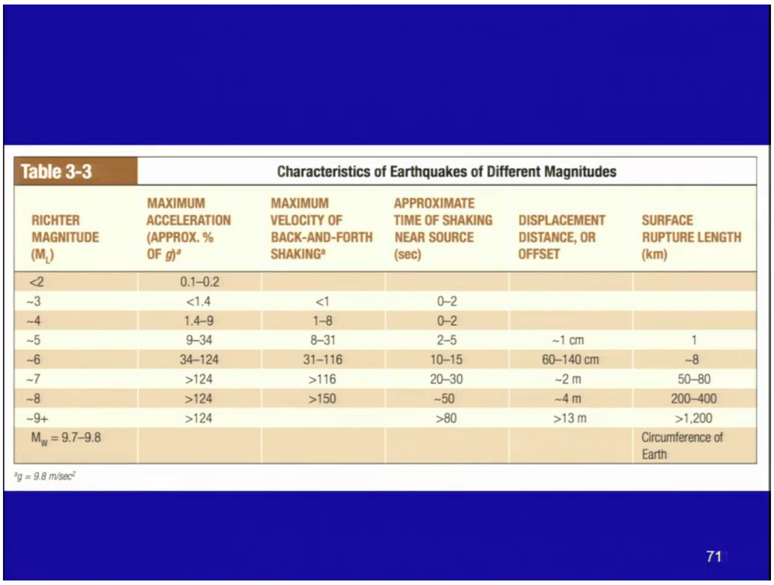

Table 3-3 Characteristics of Earthquakes of Different Magnitudes

RICHTER MAGNITUDE (M_L)	MAXIMUM ACCELERATION (APPROX. % OF g)[a]	MAXIMUM VELOCITY OF BACK-AND-FORTH SHAKING[a]	APPROXIMATE TIME OF SHAKING NEAR SOURCE (sec)	DISPLACEMENT DISTANCE, OR OFFSET	SURFACE RUPTURE LENGTH (km)
<2	0.1–0.2				
~3	<1.4	<1	0–2		
~4	1.4–9	1–8	0–2		
~5	9–34	8–31	2–5	~1 cm	1
~6	34–124	31–116	10–15	60–140 cm	~8
~7	>124	>116	20–30	~2 m	50–80
~8	>124	>150	~50	~4 m	200–400
~9+	>124		>80	>13 m	>1,200
M_W = 9.7–9.8					Circumference of Earth

[a] $g = 9.8$ m/sec^2

Now, this all is important because the ground shaking of different magnitude will vary from place to place and that will be dependent on how far you are sitting away from the source. Second is that depending on the lithology that is what ground conditions if it is softer than the ground acceleration will be different, if it is hard rocks than the ground conditions will be or ground shaking will be different.

Apart from that how much will be the shaking that is time of shaking will go on and that varies depending on the magnitude. That varies depending on the material in which the ground shaking is a speed, that will result into the damage pattern or that will affect the area accordingly. Also on the geologist are the or the people who are dealing with seismic hazard assessment will also be interested in knowing that how much will be the displacement and the distance, how much will be the rap talent depending on that you can fix up the magnitude.

Now, this all information research groups keep on collecting day by day when they experience the new events. But at the same time they try to get back in to the history based on the surface manifestations of the earthquake features. And then talk about that what is the expected magnitude in that particular area. That is what we are talking about the preparedness capacity building and that will help us in minimizing the hazard part.

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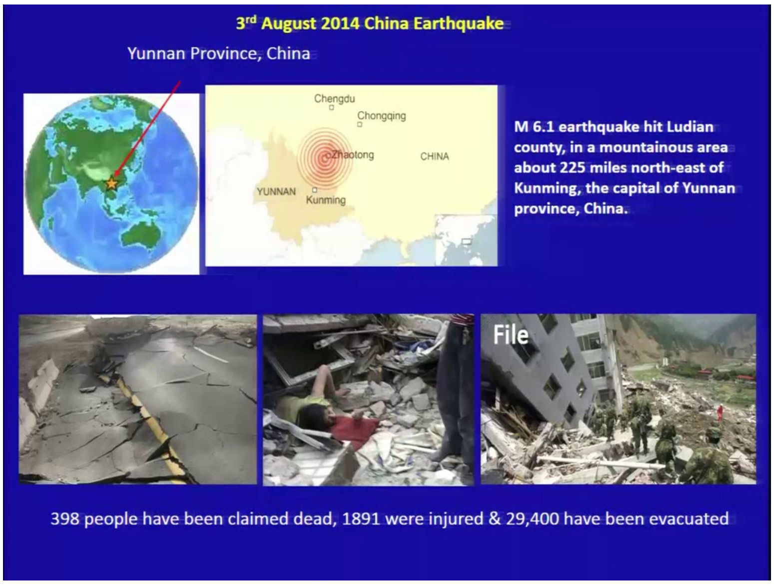

This an example from China August 3rd 2014 earthquake magnitude was 6.1, the damage was again massive.

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Pattern of damage in Kachchh due to 2001 Bhuj earthquake magnitude 7.8 in the epicentre area where maximum ground shaking was experienced. The land was broken in different like multiple fractures, this is what we call lateral spreading also. Because the most of the area was occupied by the soft deposit the area also experienced the liquefaction. Now about this process we will talk later when we are talking about ground affects. Or this liquefaction is the part of the ground affects caused by strong seismic shaking for earthquake related shaking.

This one picture aerial photograph from Gandhiram area near the coast and the black dots which you see here are all are the sealed and fine sand material poured out on the surface. And the whitish part which you see is the salt forming. So, similarly what you see here the water was been gushed out or poured out along with sediments because of strong ground shaking. We also termed this as an sand loss very much similar to the volcanic cones. The damage was extremely severe many villages towns where paced to ground.

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Sight effect can also damage the buildings not only just collapsed, but it also allows to building to sink down completely. This is an example from 1964 Niigata earthquake of 7.6 where the building got tilted as you see here this was because of a massively fraction. This soil or the foundation of the material on which this building was standing lost its share trend because of strong ground shaking. So, this another issue which massively we can face in Indo Gangetic plain because of if there is an earthquake which has been triggered along Himalaya could result into such type damage related to liquefaction.

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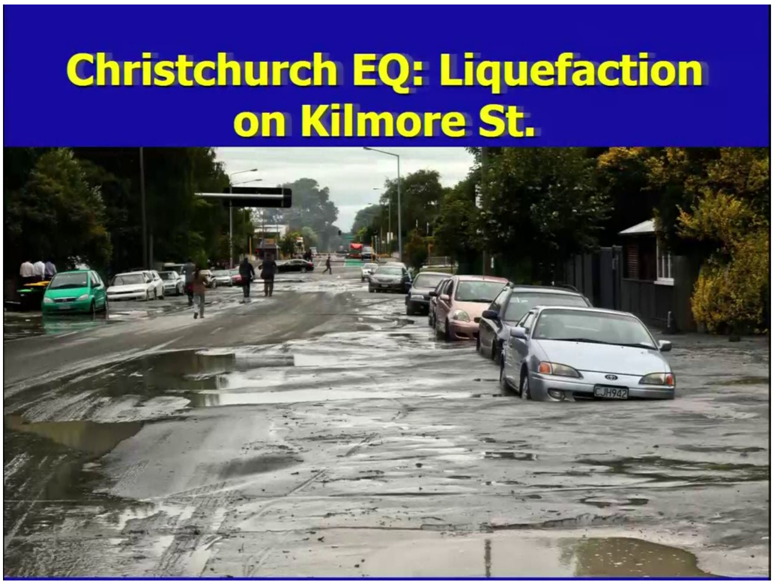

This is from Christchurch earthquake in New Zealand.

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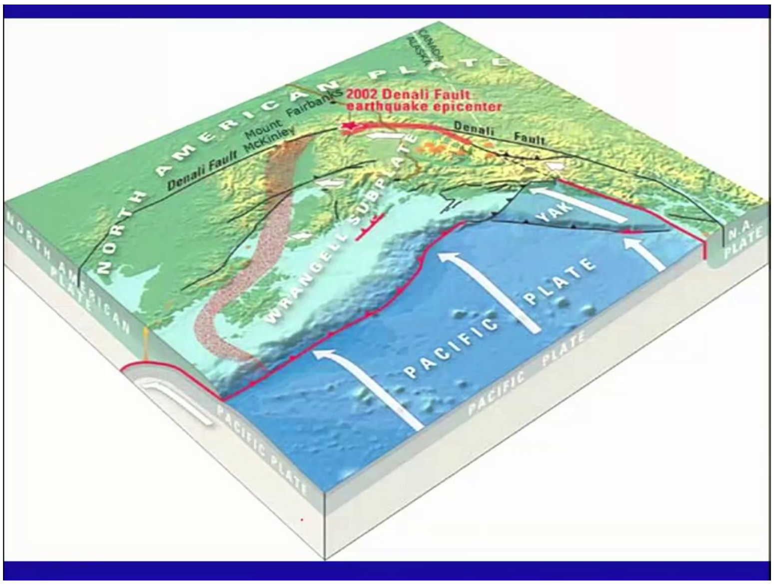

This is one of the best example which usually admire is that how the geologist or the seismologist where well prepared because they understood the phenomena. And they predicted that what will happen in future if an earthquake of similar magnitude occurs along a particular fault. So, on earth surface there are locations which will have earthquake a related faulting or the surface ruptures. And this fault lines occurs in most of the areas where the activity is quite prone.

So, seismically active regions will have fault lines which we cannot avoid we have to live with it and if any construction is been done we try be away from such fault lines. Because this will, this fault lines or the area will get rupture or the surface will get rupture or fracture during the next earthquake. So, identification of self-fault lines extremely important at the same time need to understand that what will be the expected magnitude on such fault lines and what will be the sense of movement on such fault lines. So, the geologist and seismologist they worked very hard on this and the project was and this area over of to transport the crude oil through pipe lines.

Now just I am giving in background of this area is that what we were talking about the seismic played boundaries, this is a played boundary between two plates again pacific plate and you are having North American plate. So, this is the boundary between that and this plate is subjecting below that is pacific plate is subjecting below the North American plate. So, because of the deformation which is caused by subduction here lot of fractures or the fault lines have evolved and have also resulted or caused earthquakes in past. So, they were quite sure that since these are been identified as an active four lines they have potential to trigger earthquake in near future. So, the pipeline was aligned across the Daniela, Denali fault.

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Taking it all in Slide —
How the Trans-Alaska Pipeline Survived a Big One

Compiled by Heather Friesen

The Nov. 3, 2002, magnitude-7.9 central Alaska earthquake was one of the largest recorded earthquakes in our nation's history. The epicenter of the temblor was located near Denali National Park, approximately 75 miles south of Fairbanks and 176 miles north of Anchorage. It caused countless landslides and road closures, but minimal structural damage, and amazingly, few injuries and no deaths.

In contrast, the 1906 magnitude-7.9 earthquake and subsequent fires took 3,000 lives and caused $524 million in property losses. The remote location of the magnitude-7.9 Denali Fault earthquake played a role in ensuring that the earthquake was not more devastating. However, advanced seismic monitoring, long-term research and a commitment to hazard preparedness and mitigation also played a key role. The science done before the Denali Fault earthquake aided in the successful performance of the Alaska pipeline, and the science done after the Denali Fault earthquake revealed more about large quakes that will help save lives and property during future temblors, especially in populated areas.

USGS seismologists and geologists serving on a federal task force were instrumental to ensuring that the Trans-Alaska Pipeline was designed and built to withstand the effects of a magnitude-8.0 earthquake with up to 20 feet of movement at the pipeline. The USGS design guidance proved to be on target. In 2002, the Denali Fault ruptured beneath the pipeline, resulting in an 18-foot horizontal offset. The resilience of the pipeline is a testament to the importance of science in hazard mitigation and decision making.

More than 30 years ago, Trans-Alaska Pipeline System (TAPS), formed by seven oil companies, confirmed the existence of a great deal of oil on the North Slope. In February 1969, TAPS announced plans to build a 4-foot-diameter, 800-mile pipeline to carry crude oil from Prudhoe Bay to Valdez. Issues pertaining to the safety of the design emerged. Would the heat in the oil melt the pervasive, thick, permafrost layer and cause damaging spills? Would the pipeline be able to withstand a large earthquake in the nation's most seismically active state?

Designed to withstand a magnitude-8 earthquake with up to 20 feet of movement, the Trans-Alaska Pipeline is supported by rails on which it can slide freely during an earthquake.

Walter Hickel, then U.S. Secretary of the Interior (1969-70), was alerted about the proposed pipeline and immediately appointed Bill Pecora, then USGS director (1965-71), to chair a technical advisory board. Pecora appointed the Menlo Park working group, made up mostly of USGS scientists, to advise the board.

USGS created several scientific documents to be used in planning the pipeline location and construction. Documents included an estimate of potential earthquake shaking levels and a report on thermal effects of a heated pipeline in permafrost that described how the pipe would float, twist and break.

In 1971, Pecora brought the Menlo Park group to Washington and thanked them for telling the oil companies "what they can't do," but now he wanted them to tell the companies "what they can do." Pecora locked the door of the conference room and told the group that he would not let them out until they had finished the analysis of the question "To bury or not to bury?" So the group put together the necessary stipulations on the pipeline construction. Among other things, the stipulations required that the pipeline system be designed to prevent oil leakage from the effects of a magnitude-8.0 earthquake on the Denali Fault.

In April 1974, construction of a 400-mile, all-weather road from the Yukon River to Prudhoe Bay was started. Pipeline and storage tank construction at Valdez began in 1975. Large segments of the Trans-Alaska Pipeline were elevated above ground to keep the permafrost from melting, and about half of the 800-mile pipeline was buried. A special fault design was adopted for crossing the Denali Fault Zone. Here the pipeline is supported by rails on which it can slide freely in the event of fault offset. In mid-1977, the first tanker shipped Alaska north slope oil from Valdez.

More than 14 billion barrels (nearly 550 billion gallons) have moved through the pipeline since startup in 1977. After the 2002 quake, the pipeline continued to carry 1 million barrels of oil each day, though it was temporarily shut down for inspection. With the pipeline intact, an important source of revenue for the state of Alaska was preserved. Moreover, as Alaskans know all too well, the consequences to the environment, should the pipeline have failed, would have been catastrophic.

"Good science made the difference between an emergency and a tragedy," said P. Patrick Leahy, USGS. "It's an example of how partnerships between the USGS, the Federal Emergency Management Agency, universities, state and local officials, and business leaders and the community enable us to apply our scientific knowledge. We know we can't stop the Earth from changing, but we can work together making public safety our primary goal."

The 2002 Denali earthquake is the largest seismic event ever recorded on the Denali Fault system — one of the longest continental faults in the world. The earthquake was similar to the magnitude-7.9 1906 earthquake, which ruptured the San Andreas Fault in Northern California. Both fault systems exhibit strike-slip movement, where blocks of continental crust slip horizontally past each other.

"Studying the 2002 Denali Fault earthquake is an opportunity to understand the consequences of a very large earthquake to better prepare for the time when one will occur in a much more densely populated area," said USGS scientist Peter Haeussler.

The Denali Fault earthquake was very directional. It ruptured rapidly over a long distance, focusing the earthquake energy in the direction of the earthquake

Now this Denali fault was identified as an active and also they knew that what is the sense of movement along this fault that is the Denali fault. And if at all it is flips in future how much is the expected displacement they are going to experience.

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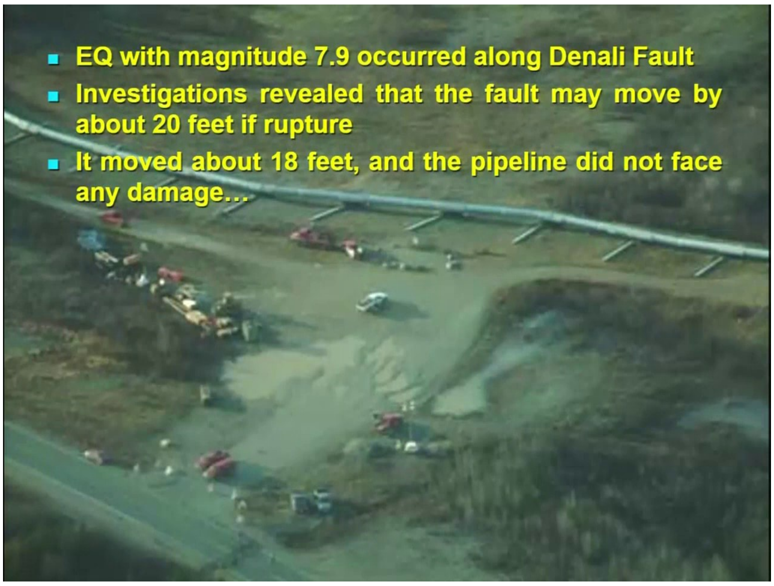

So, what they decided that earlier the pipeline was been planned to be put underground. But since they knew that this is an active fault where the fault line is crossing and this fault may move in near future. So, they decided to put the pipeline on surface over a roller coasters and the pipe which was used for that transact was quite flexible in sense. So, they used different material, they used they brought the pipeline on surface they put the pipeline on the roller coaster; with an understanding then earthquake with magnitude 7.9 or 8 will occur on this.

And this happened earthquake was triggered with magnitude 7.9 on Denali fault, the investigation before the earthquake and before putting this pipeline suggested that the fault may move by about 20 feet. If it ruptures it moved 18 feet and the pipeline did not face any damage. So, this is how we were talking about that if you know and understand the hazard you can minimize the loss fault. So, the one of the good example; I will stop here. And we will continue in the next lecture and talk more about the earthquakes.